Hydrologic budgets of the two Olentangy River experimental wetlands, 1994-99

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Introduction

Since 1994, as part of a long-term wetland and ecosystem study , a combination of manual and automated observations of the hydrologic system has been providing a wealth of information on the daily, and even hourly, water fluxes of the two experimental wetlands at the Olentangy River Wetland Research Park (ORWRP).

Nairn et al. (1996) calculated hydrologic budgets for 1995. In particular, Mitsch (1996) presented flooding events based on USGS calibration, and, Wu et al. (1995) provided a modeling approach of hydrologic budgets for the two experimental wetlands at ORWRP. Furthermore, Wang et al. (1997) improved the hydrologic modeling approach and gave a detailed of instructions for producing a hydrologic database for the two experimental wetlands at. ORWRP. Wang et al. (1998), Wang and Mitsch (1999) and Zhang et al. (2000) followed the approach of Wang et al.(1997) and presented hydrologic budgets from 1997 to 1999. These studies, however, provided only estimates of daily water fluxes and flooding events of the two Oentangy River experimental wetlands for each year. There is a need to present calibration methods.

Methods

Daily hydrologic budgets were determined by the following equation (Mitsch and Gosselink, 2000) for wetland 1(W1) and wetland 2 (W2) (Figure 1) from 1994 to 1999:

$$S_i + F_i + P - S_o - ET - G_o - \Delta V = 0 \qquad (1)$$

where,

S_i = pumped inflow (surface)
F_i = flood inflow (due to floods on the Olentangy River)
P = precipitation
S_o = surface outflow
ET = evapotranspiration
G_o = groundwater outflow (seepage)
ΔV = change in volume

All parameters, including twice-daily (morning and evening) pumped inflow readings, flood inflow from the Olentangy River, daily precipitation and evapotranspiration extracted from the ORWRP weather station (Mitsch, et al. 1996), daily surface outflow based on twice-daily staff gauge readings and calibration equations (Wang and Mitsch, 1998; Zhang et al., 2000), were developed for the hydrologic budgets during the years 1994 to 1999.

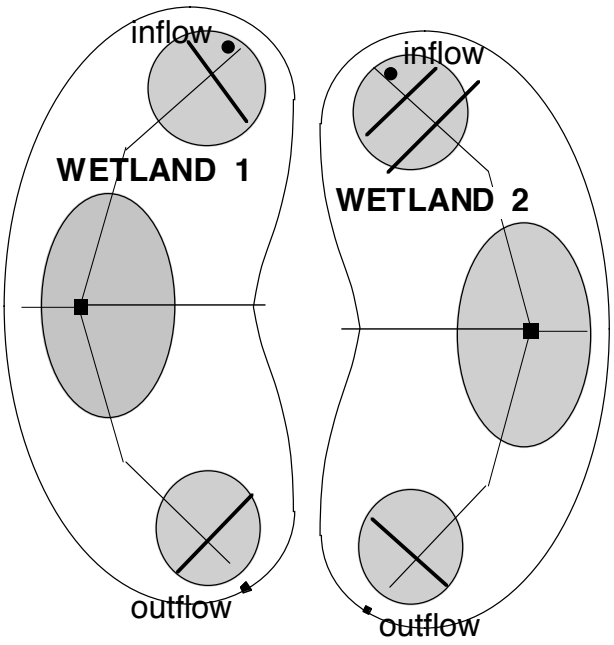

Figure 1. Location of pumped inflow and outflow of Wetland 1 and Wetland 2 at ORWRP.

During the inflow and outflow calibration, the following factors affecting ORWRP hydrology were considered, 1994-99:

1. chronology of outflow weir change and other major hydrology events (Table 1);
2. Staff gauge readings of crests for various weir settings, 1994-99 (Table 2);
3. Calibrated staff gauge readings above sea elevation during the study period (Table 3); and
4. Calibration of velocity readings (Swoffer Instrument Co. Model 1200 current meter) and water surface level for outflow.

Table 1. Chronology of outflow weir changes and other major hydrology events affecting ORWRP hydrology during 1994-99.

Date and time	Pump changed	Weir code	Date and time	Pump changed	Weir code	Date and time	Pump changed	Weir code
1994			**1997**			**1999**		
3/3/94 15:30	on	V+2	1/28/97 18:15	off	V+2	1/20/99 8:45	off	no weir
3/5/94 15:23	off	V+2	1/29/97 14:00	on	V+1	1/20/99 16:45	on	no weir
3/18/94 14:10	on	V+1	3/12/97 11:00	off	V+2	1/21/99 8:35	off	no weir
3/19/94 16:00	off	V+1	3/14/97 11:30	on	no weir	1/21/99 19:15	on	no weir
4/11/94 16:20	on	V+1	5/11/97 17:35	off	no weir	1/22/99 8:40	off	no weir
5/6/94 10:35	on	V+0	5/17/97 11:07	on	no weir	1/22/99 10:51	on	no weir
5/11/94 18:05	off	V+0	5/18/97 16:55	off	no weir	1/22/99 15:10	off	no weir
5/11/94 20:20	off	no weir	5/23/97 14:30	on	no weir	1/22/99 15:25	on	no weir
5/14/94 0:00	off	no weir	5/23/97 16:00	off	no weir	1/23/99 8:10	off	no weir
5/16/94 20:00	on	no weir	5/27/97 17:53	on	no weir	1/23/99 12:00	on	no weir
5/25/94 15:40	on	V+0	6/1/97 23:00	-	no weir	1/25/99 7:27	off	no weir
5/25/94 11:15	on	V+1	8/25/97 11:30	off	no weir	1/25/99 10:00	on	no weir
5/26/94 8:45	on	V+0	9/4/97 15:40	on	no weir	1/25/99 10:35	off	no weir
5/26/94 18:50	on	no weir	9/6/97 11:28	off	no weir	1/25/99 10:45	on	no weir
6/5/94 10:20	on	V+0	9/8/97 19:34	on	no weir	1/25/99 16:00	off	no weir
7/29/94 13:55	on	no weir	9/14/97 15:00	on	V+0	1/25/99 16:05	on	no weir
8/20/94 7:40	on	V+0	9/16/97 9:35	on	V+1	1/28/99 8:00	off	no weir
8/26/94 11:30	on	V+1	9/17/97 14:00	on	V+0	1/28/99 0:00	on	no weir
9/6/94 17:45	on	no weir	11/22/97 17:50	off	V+0	1/29/99 8:30	off	no weir
10/15/94 11:08	on	V+0	11/24/97 10:00	on	V+0	1/29/99 8:50	on	no weir
10/23/94	on	V+0	**1998**			2/10/99 17:25	off	no weir
10/28/94 10:30	on	no weir	1/1/98 8:00	off	v+0	2/10/99 18:28	on	no weir
10/30/94 14:45	on	V+0	1/3/98 12:08	on	v+0	2/16/99 9:00	off	no weir
12/19/94 17:00	on	no weir	1/19/98 12:00	off	v+0	2/16/99 18:15	on	no weir
12/20/94 17:21	off	no weir	1/19/98 17:00	on	v+0	3/5/99 8:15	off	no weir
1995			2/4/98 9:10	off	v+0	3/5/99 10:00	on	no weir
2/26/95 17:05	on	no weir	2/4/98 16:00	on	v+0	3/9/99 9:50	off	no weir
2/27/95 9:30	off	no weir	3/11/98 9:15	off	v+0	3/9/99 9:55	on	no weir
3/8/95 17:08	on	V+0	3/11/98 16:00	on	v+0	3/16/99 14:45	off	no weir
6/27/95	off	V+0	5/12/98 9:20	off	v+0	3/16/99 14:50	on	no weir
6/29/95 11:50	on	V+0	5/12/98 9:40	on	v+0	3/16/99 15:00	off	no weir
8/8/95	on	V+0	5/13/98 15:40	off	v+0	3/16/99 15:10	on	no weir
11/24/95 16:15	off	V+0	5/14/98 8:30	on	v+0	4/23/99 19:55	off	no weir
11/17/95 16:33	off	noweir	5/16/98 10:00	off	v+0	4/30/99 10:30	on	no weir
1996			5/16/98 11:10	on	v+0	6/6/99 9:30	off	no weir
3/6/96 10:05	on	noweir	6/29/98 10:50		no weir	6/8/99 18:25	on	no weir
3/12/96 9:30	on	V+0	8/24/98 19:16	off	no weir	6/23/99 8:50	off	no weir
4/23/96 on	V+0		8/28/98 11:45	on	no weir	6/23/99 18:00	on	no weir
4/26/96 11:50	off	V+0	9/15/98 9:12	off	no weir	7/1/99 8:30	off	no weir
4/29/96 off	V+0		9/18/98 17:50	on	no weir	7/2/99 0:00	on	no weir
5/11/96 -5/12/96	off	V+0	9/18/98 18:10	off	no weir	7/9/99 8:25	off	no weir
5/25/96 16:00	off	noweir	9/18/98 19:00	on	no weir	7/9/99 8:30	on	no weir
7/4/96 13;53	on	noweir	10/5/98 18:35	off	no weir	7/25/99 9:35	off	no weir
8/15/96	on	no weir	10/9/98 16:50	on	no weir	7/25/99 10:09	on	no weir
10/1/96 16:00	on	V+1	10/22/98 10:20	off	no weir	8/6/99 19:00	off	no weir
			10/22/98 10:35	on	no weir	8/9/99 10:55	on	no weir
			10/29/98 10:30	off	no weir	8/24/99 10:15	off	no weir
			10/29/98 10:40	on	no weir	8/26/99 9:26	on	no weir
			11/4/98 17:30	off	no weir	8/26/99 11:20	off	no weir
			11/5/98 11:00	on	no weir	8/27/99 15:30	on	no weir
			11/6/98 8:45	off	no weir	10/24/99 10:15	off	no weir
			11/8/98 16:30	on	no weir	10/24/99 10:15	on	no weir
			12/28/98 9:05	off	no weir	12/17/99 13:17	off	no weir
			12/29/98 13:17	on	no weir	12/17/99 13:20	on	no weir

*Weir code from Wang and Mitsch, 1999

Table 2. Staff gage readings of crests for various weir settings, 1994-99.

Weir setting	1994		1995		1996		1997		1998		1999	
	W1	W2	W1	W2	W1	W2	W1	W2	W1	W2	W1	W2
weir plus 2 slats	1.81	1.89	*	*	*	*	1.63	1.84	1.63	1.84	*	*
weir plus 1 slat	1.35	1.47	*	*	1.34	1.92	1.21	1.42	1.21	1.42	*	*
weir only	0.96	1.02	0.82	0.90	0.92	1.17	0.79	1.00	0.79	1.00	*	*
no weir	0.46	0.52	0.32	0.40	0.42	0.42	0.29	0.50	0.29	0.50	0.29	0.52

* not used
Weir setting (Wang and Mitsch, 1999)

Table 3. Calibrated staff gauge readings above sea elevation during the study period.

	1996				1998				1999			
	W1		W2		W1		W2		W1		W2	
	a	b	a	b	a	b	a	b	a	b	a	b
3' on staff gauge	727.46	3.00	727.36	3.00	728.37	3.90	728.24	3.83	726.79	3.00	726.78	3.00

a: ft above MSL
b: staff gage reading

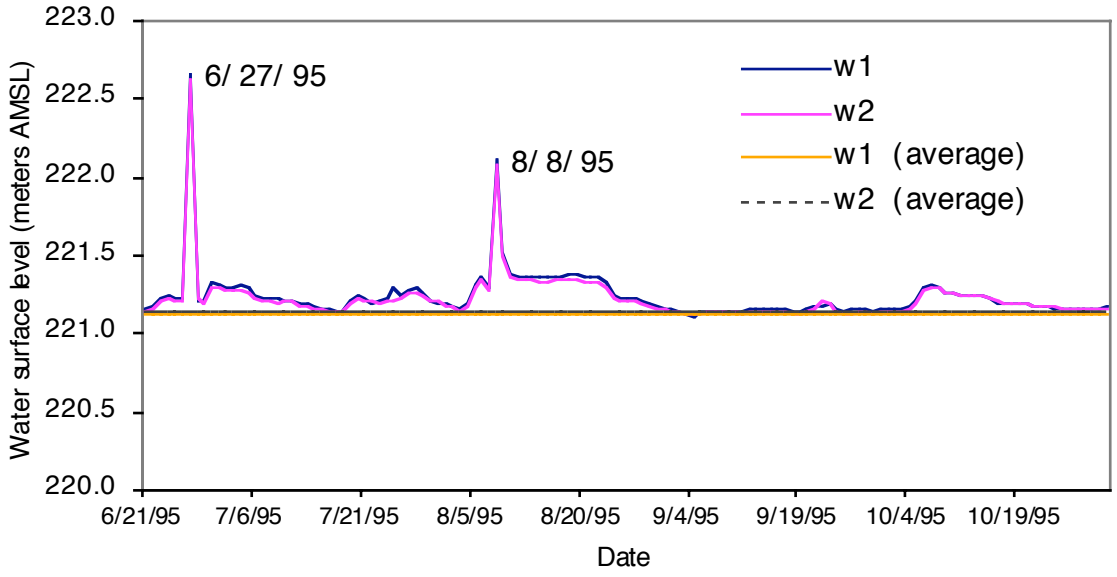

Figure 2. Water surface level of W1 and W2 during the flooding period of 1995.

Table 4. Mean daily hydrologic budgets for W1 and W2, 1994-99.

Hydrologic Components	1994		1995		1996		1997		1998		1999	
	W1	W2	W1	W2	W 1	W2	W 1	W2	W1	W2	W1	W2
m3/day												
INFLOW												
Pumping	1152	1136	1053	1038	557	583	937	940	1006	1001	825	857
precip.	30	30	32	32	35	35	31	31	19	19	16	16
flood	0	0	325	325	33	20	4	4	0	0	0	0
OUTFLOW												
Surface	935	910	1082	984	450	444	741	647	978	837	775	817
Evapotrans.	21	21	19	19	22	22	31	31	30	30	24	24
seepage	220	220	-	-	152	126	274	247	36	175	45	44
flood	0	0	325	325	-	-	-	-	-	-	-	-
$^{\Delta}$volume	0	0	0	0	8	10	-8	-10	-2	-3	-3	-1
Residual	6	76	-16	68	-7	37	-62	-62	0	0	0	0

Table 5. Percentage monthly inflow of total annual inflow for W1 and W2, 1994-99.

Month	1994		1995		1996		1997		1998		1999	
	W1	W2	W1	W2	W1	W2	W1	W2	W1	W2	W1	W2
Jan							9	9	8	8	13	14
Feb							11	11	11	11	12	12
Mar	3	3	13	13	15	16	13	13	14	14	13	13
Apr	16	16	13	13	9	7	9	9	12	13	7	7
May	14	13	13	13	3	2	9	9	7	6	10	10
Jun	8	7	13	12	12	12	10	10	10	10	5	4
Jul	10	10	11	11	9	10	6	6	10	11	11	10
Aug	9	9	19	19	9	10	5	5	5	5	4	4
Sept	8	8	5	5	11	10	9	9	2	2	4	3
Oct	16	16	10	10	13	13	4	4	9	8	3	3
Nov	10	10	3	3	7	8	7	7	8	7	5	5
Dec	8	8	0	0	11	12	8	8	4	4	12	13
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Results and Discussion

Table 4 summarizes mean daily hydrologic budgets for 1994-99, and shows:

1. Generally, greater than 95% of daily inflow received from pumped inflow, 1994-99; except for special flooding hydroperiods (Figure 2) that occurred on June 27, 1995 and August 8, 1995.
2. daily inflow of W1 approximately equals daily inflow of W2.; and
3. greater than 80% surface outflow was produced by pumped inflow, except in 1995 (outflow > pumped inflow) because of 100-year flooding events.

There were no floods in 1994, 1998 or 1999 (Wang et al., 1997; Wang and Mitsch, 1998; and Zhang et al., 2000). There were two floods on the site in 1995 (Figure 2). In particular, on June 27, a major flood, near the 100-year flood event, occurred on The Olentangy River (Mitsch, 1996). Three small floods and flood events in 1996 occurred on April 23 and 29, and May 11. Water surface level was 221.37 m and 221.41 m for W 1 and W 2 on April 23, 1996, respectively; 221.34 m and 221.72 on May 11, 1996 for W 1 and W 2, respectively. Flood water flowed (100 gpm) into W1 only on June 1, 1997 (Wang et al., 1998).

Monthly hydrologic budgets for 1994-99 followed the same pattern as daily hydrologic budgets. Table 5 shows percentage of monthly inflow from total pumped inflow 94-99. Generally, greater than 50% inflow from total pumped river water was received in spring and early summer (Figure 3). In early years (January to March, 95-96), the experimental wetland road constraction resulted in absence of pumped inflow and caused monthly pumped inflow patterns to be different from other years (Figure 3).

Figure 4 shows annual inflow and outflow for W1 and

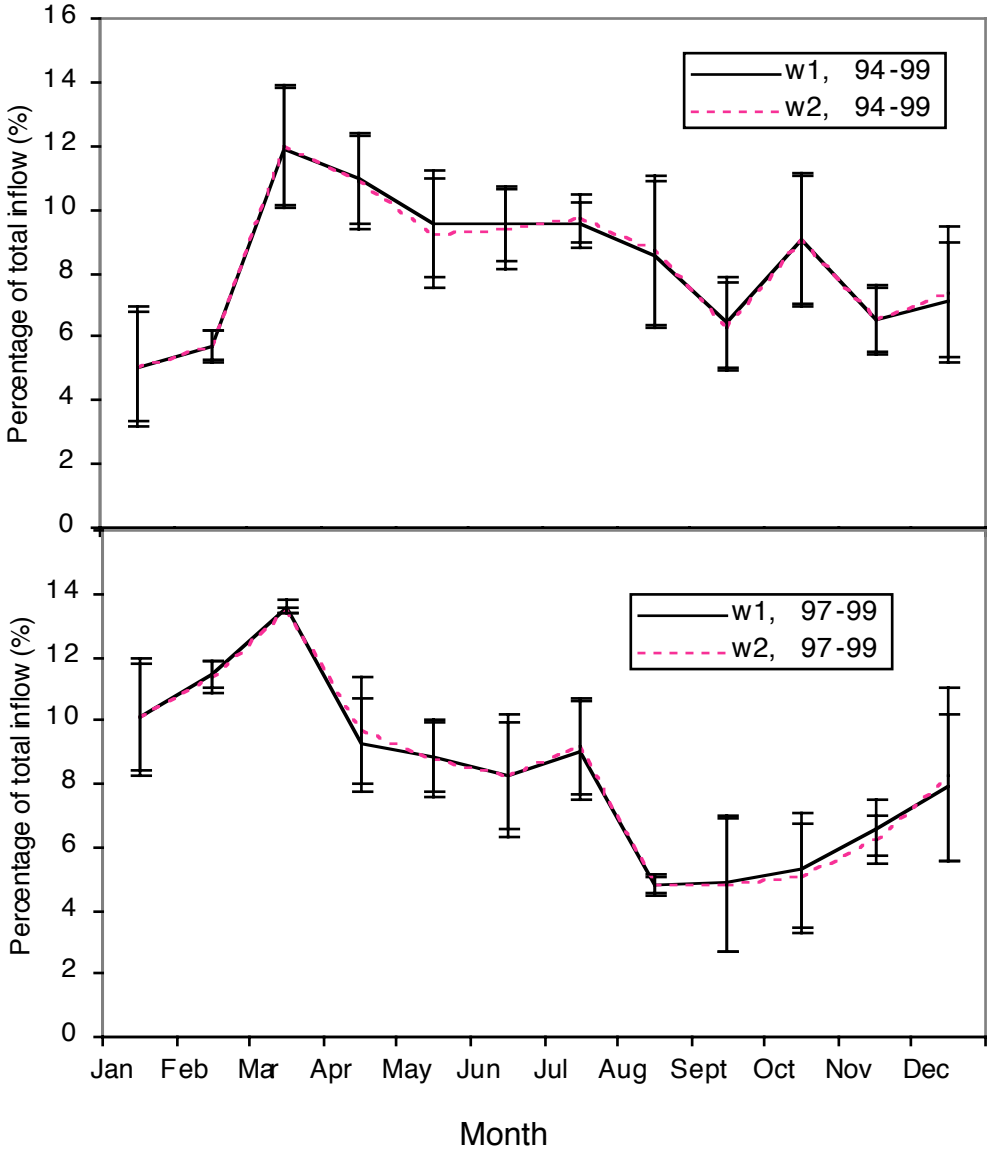

Figure 3. Monthly percentage of total inflow with standed errors for W1 and W2, 1994-99 and 1997-99.

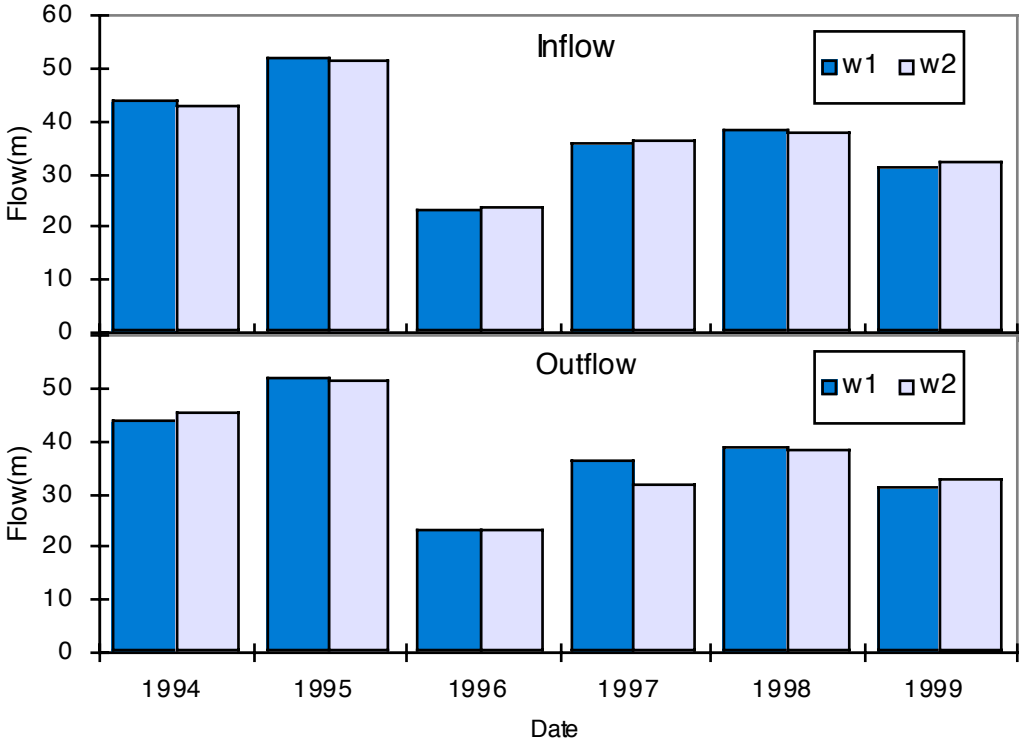

Figure 4. Inflow and outflow (meters) for W1 and W2, 1994-99.

W2. Annual outflow patterns generally followed annual inflow patterns with the largest outflow occurring in 1995 because of impacts of 100-year flooding events.

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